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US 5975428 A

(58) Field of Search

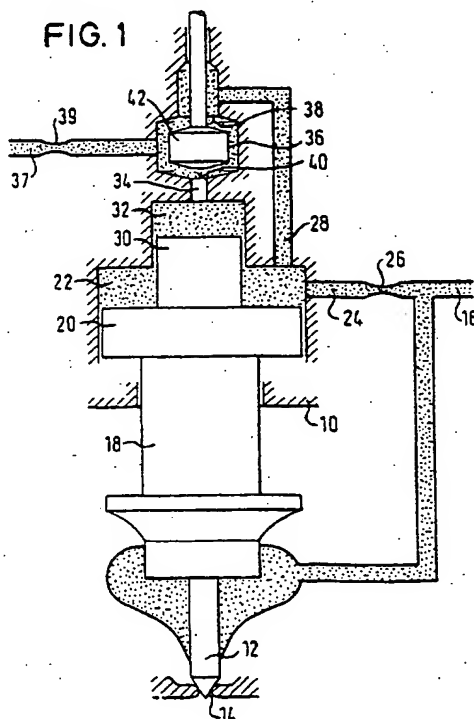
UK CL (Edition R ) F1B B2JCB B2JCN  
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(54) Abstract Title

**Fuel-injection valve**

(57) In the case of a fuel-injection valve having a valve body (10), a nozzle needle (12), which is disposed in a displaceable manner in the valve body (10), an actuating part (18), which is connected to the nozzle needle (12) and protrudes into a control pressure space (22), and a control valve (38, 40, 42) which can control the pressure in the control pressure space (22), it is possible to open the nozzle needle partially for any period of time. For this purpose, the actuating part (18) is provided with a holding piston (30) which can be displaced in a holding chamber (32), and the control valve is a 3 port, 3 position directional control valve which controls both an outlet of the control pressure space and also an outlet of the holding chamber.

FIG. 1



GB 2 353 567 A

1/2

FIG. 1

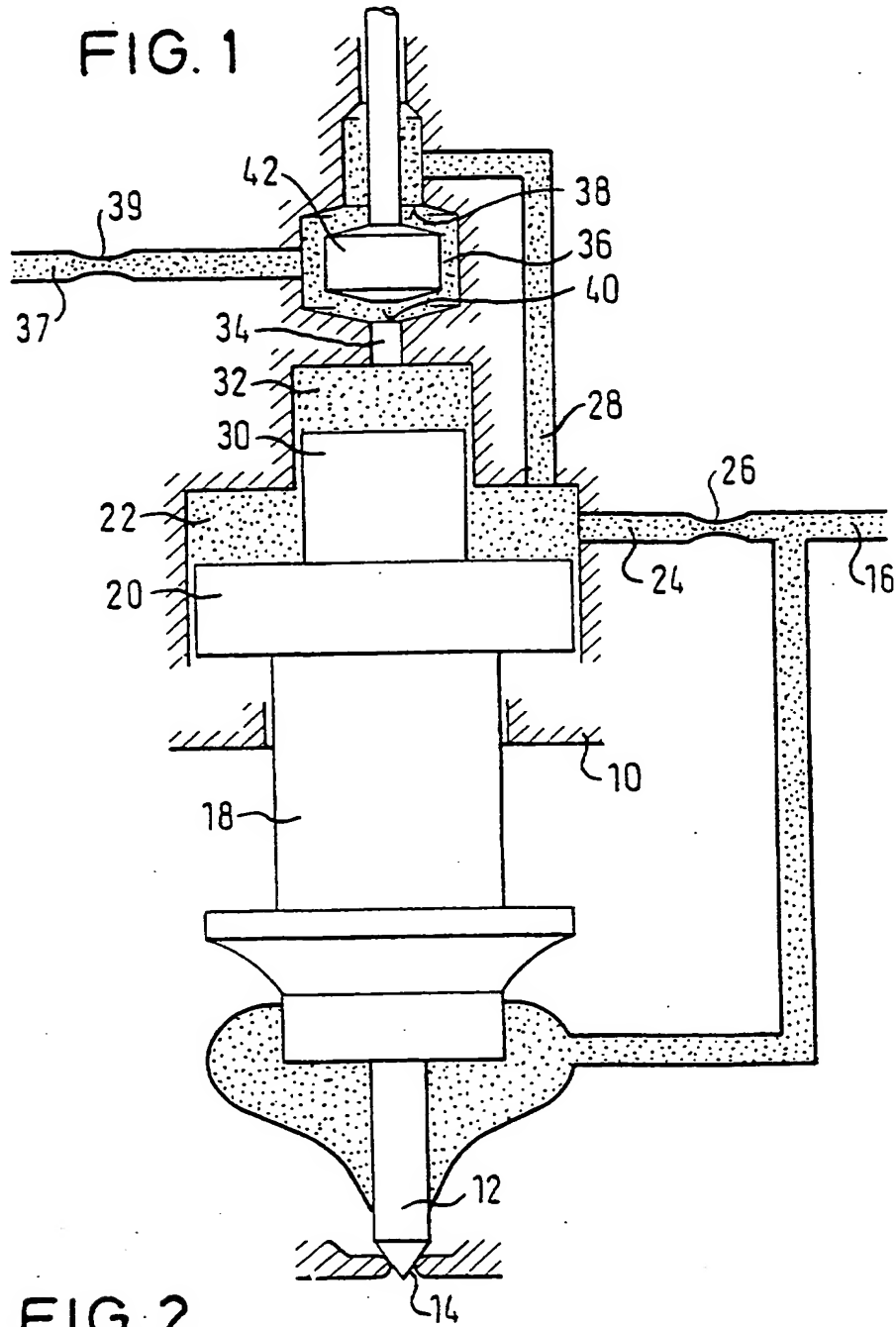


FIG. 2

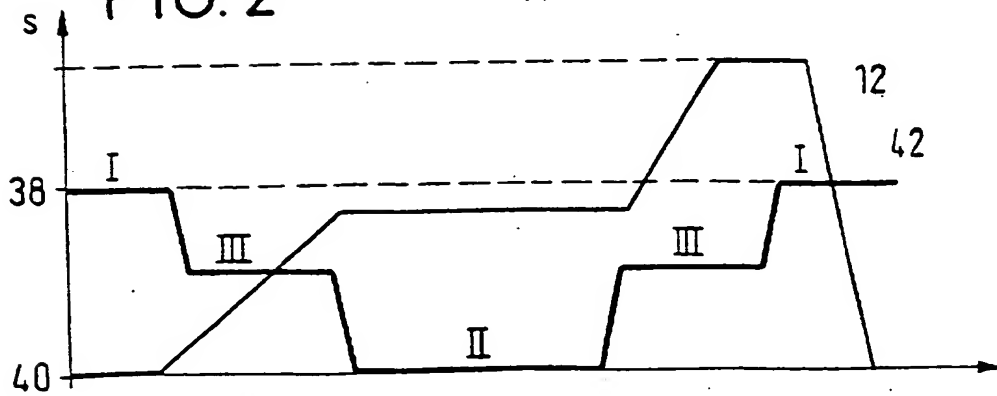
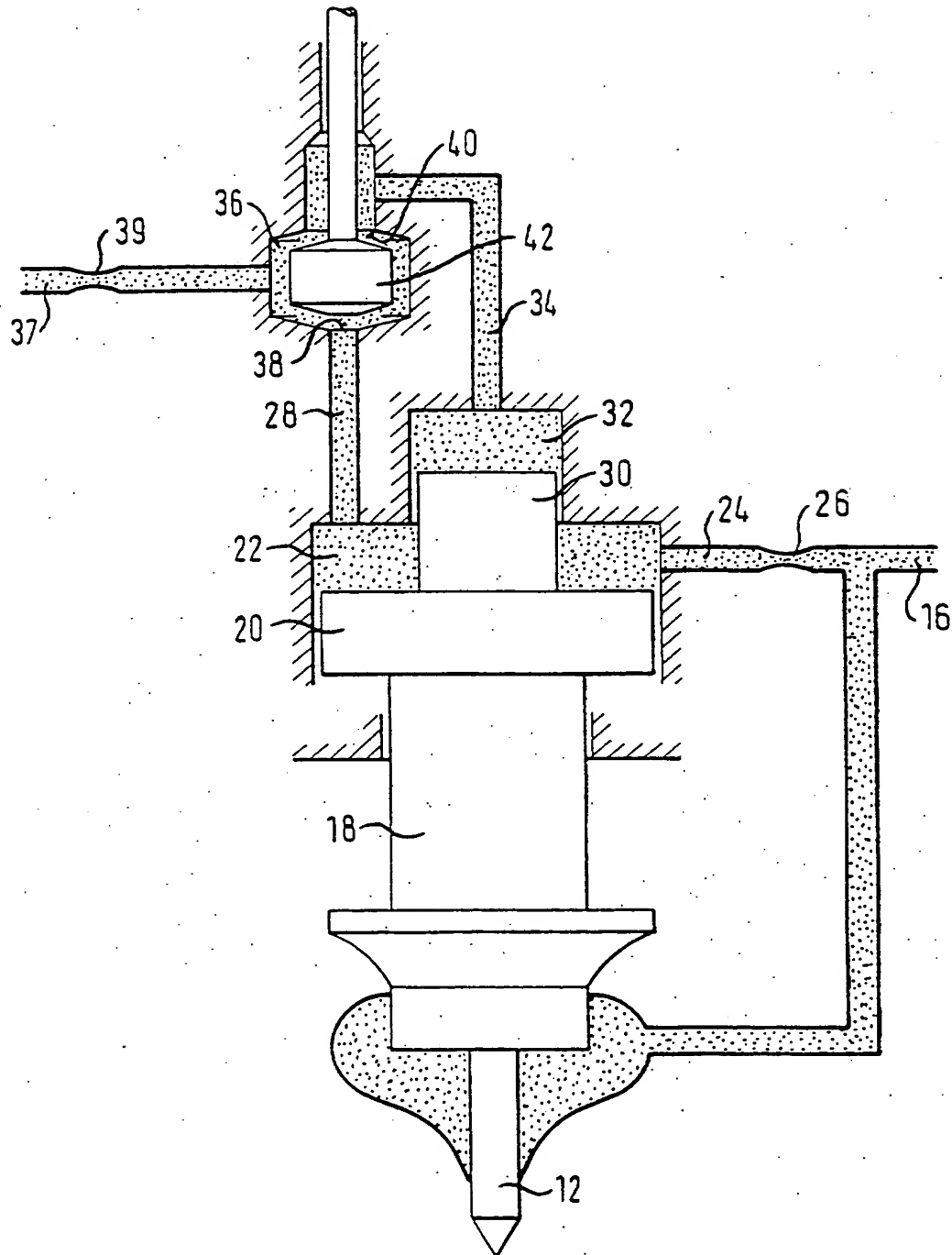


FIG. 3



DESCRIPTIONFUEL-INJECTION VALVE

The invention relates to a fuel-injection valve having a valve body, a nozzle needle, which is disposed in a displaceable manner in the valve body, an actuating part, which is connected to the nozzle needle and protrudes into a control pressure space, and a control valve which can control the pressure in the control pressure space.

This type of fuel-injection valve is disclosed in DE 196 24 001 A1 and comprises an outlet from the control pressure space which issues in a control chamber of the control valve. The control chamber is provided with two mutually opposite valve seats with which a valve needle can cooperate. One of the valve seats is allocated to the outlet from the control pressure space and the other valve seat is allocated to an outlet from the control chamber. Thus, the outlet from the control pressure space is always closed if the valve needle lies against one of the valve seats. This design of the control valve renders it possible to perform a preliminary injection of fuel with a comparatively low level of outlay. In the starting condition, the valve needle lies against one of the valve seats, so that the fuel supplied to the control pressure space is accumulated therein. The closing force thereby exerted upon the actuating force holds the nozzle needle of the fuel-injection valve in a closed position. If, starting from this position, the valve needle is raised from the corresponding valve seat, is moved through the valve chamber and into position against the opposite-lying valve seat, the fuel located in

the control pressure space can flow away therefrom during the period of time in which the valve needle is not lying against any of the two valve seats. During this period of time, the closing force exerted upon the actuating part is reduced to such an extent that the opening force acting upon the nozzle needle can serve to raise the nozzle needle from the associated valve seat, so that fuel is injected. The valve needle is moved from its position lying against the first valve seat to its position lying against the second valve seat at such a speed that a small quantity of fuel is injected which corresponds to a preliminary injection. Once the valve needle is located lying against the second valve seat, it remains in this position for a period time which corresponds to the so-called injection-interruption between the preliminary injection and the main-injection process. Subsequently, the valve needle is displaced in the direction towards the first valve seat, wherein, in contrast to the movement during the preliminary injection, it remains for a longer period of time in a position in the middle of the control chamber, in which it does not lie against either the first or the second valve seat. In this position, fuel is able to escape from the control pressure space by opening the nozzle needle completely for a longer period of time, so that it is possible to perform the main-injection process. In order to terminate the main-injection process, the valve needle is returned to its original position.

In accordance with the present invention there is provided a fuel-injection valve having a valve body, a nozzle needle, which is disposed in a displaceable manner in the valve body, an actuating part, which is connected to the nozzle

needle and protrudes into a control pressure space, and a control valve which can control the pressure in the control space, the actuating part having a holding piston which can be displaced in a holding chamber and the control valve being a 3 port, 3 position directional control valve which controls both the outlet of the control pressure space and also the outlet of the holding chamber.

Such a fuel-injection valve has the advantage that by suitably controlling the control valve the nozzle needle can be locked in any position between its closed state and its completely open state. The control valve can actually completely block the holding chamber which, apart from the connection to the control valve, does not comprise any further inlet or outlet, so that any movement of the holding piston in the holding chamber is prevented and thus the nozzle needle is prevented from moving. In this manner, it is possible to adapt the injection to suit each operating point of the engine by controlling the period of time and the stroke of the process of opening the nozzle needle, so that optimum combustion and reduced exhaust gas emissions are achieved. In particular, a preliminary stroke of any duration and height can be achieved which is used for the purpose of the preliminary injection and then it is possible to perform a main-injection process with a completely open needle. In this manner, it is possible to achieve a so-called "boot-injection".

In accordance with a preferred embodiment of the invention, the control valve comprises a control chamber, from which issues an outlet, a control pressure space-valve seat is formed on one side of the control chamber and a holding

chamber-valve seat is formed on the other side of the control chamber, and disposed in a displaceable manner in the control chamber is a valve needle which can cooperate with the valve seats. This design renders it possible in a mechanically convenient manner to form the 3 port, 3 position directional control valve which serves both to relieve the control pressure space and to relieve the holding chamber.

Preferably, a restrictor is attached in the outlet of the control chamber. In this manner, it is possible to reduce the rate of the pressure drop in the control pressure space, which causes the nozzle needle to open more slowly. Nevertheless, it is possible for the needle to close rapidly, since the restrictor disposed in the outlet does not influence the closing speed.

The invention will be described hereinafter, by way of example only, with reference to two embodiments which are illustrated in the drawings, in which

Figure 1 is a schematic sectional view of a fuel-injection valve in accordance with the invention according to a first embodiment;

Figure 2 is a diagram plotting the stroke of the valve needle of the control valve and the resulting stroke of the nozzle needle; and

Figure 3 is a schematic view of a fuel-injection valve in accordance with the invention according to a second embodiment.

Figure 1 illustrates a schematic sectional view of a fuel-injection valve which comprises a valve body 10. Disposed in a displaceable manner therein is a nozzle needle 12 which cooperates with a valve seat 14, in order to control the injection of fuel into a cylinder of an internal combustion engine [not illustrated]. This fuel is provided via a supply line 16.

Connected to the nozzle needle 12 is an actuating part 18 whose end remote from the nozzle needle is provided with a control pressure piston 20 which is disposed in a displaceable manner in a control pressure space 22 which is provided with an inlet 24, in which a restrictor 26 is disposed, and an outlet 28. The inlet 24 is connected to the fuel supply line 16.

A holding piston 30 which is disposed in a displaceable manner in a holding chamber 32 is attached to the control pressure piston 20. The holding piston 30 together with the control pressure piston 20 form a stepped piston.

The holding chamber 32 is provided with an outlet 34 which issues into a control chamber 36 of a control valve. The outlet 28 from the control pressure space 22 also issues into the control chamber 36. The outlet 34 and the outlet 28 issue into the control pressure chamber 36 on mutually opposite sides, and in the region of the corresponding orifice there is formed a valve seat 38 and 40 respectively. An outlet 37 which is provided with a restrictor 39 issues from the control chamber 36. The outlet 37 leads to a fuel-recirculation system.

A valve needle 42 is disposed in a displaceable manner inside the control



chamber 36 such that it can be located in a first position, in which it lies against the valve seat 38 and closes the outlet 28 from the control pressure space 22, or said valve needle can be located in a second position, in which it lies against the valve seat 40 and closes the outlet 34 of the holding chamber 32, or in a third position which is illustrated in Figure 1 and in which the valve needle 42 is located approximately in the middle of the control chamber 36, so that the two valve seats 38, 40 are revealed.

The fuel-injection valve described functions in the following manner: if the valve needle 42 is located in its first position lying against the valve seat 38 (see section I of curve 42 of Figure 2 for the valve needle 42), the outlet 28 from the control pressure space 22 is closed, so that at this site the fuel supplied via the inlet 24 exerts a high pressure upon the control pressure piston 20. This pressure produces a closing force which is greater than the opening force exerted by the fuel pressure upon the nozzle needle 12; the fuel-injection valve is thus located in its closed position, in which no fuel is injected. This is illustrated in curve 12 of Figure 2 for the nozzle needle 12 by virtue of the fact that the stroke = 0.

If the valve needle 42 is moved from its first position to the third position lying against the valve seat 40 (see section III of curve 42 of Figure 2), in which position said valve needle opens both the outlet 28 from the control pressure space 22 and the outlet 34 from the holding chamber 32, the pressure in the control pressure space 22 drops, so that the closing force exerted at this site upon the control pressure piston 20 is less than the opening force exerted upon the nozzle

needle 12; the nozzle needle 12 can thus be raised from the valve seat 14. The restrictor 39 causes the pressure in the control pressure space 22 to fall slowly causing the nozzle needle 12 then to be opened in a comparatively slow manner. This is evident in Figure 2.

If the nozzle needle has performed a desired preliminary stroke, i.e. is located in a partially open position, the valve needle 42 is moved to its second position (see section II of curve 42 of Figure 2), in which it lies against the valve seat 40 and closes the outlet 34 from the holding chamber 32. Since the single outlet from the holding chamber 32 is now closed, the holding piston 30 is directly prevented from moving any further and thus the nozzle needle 12 is directly prevented from opening further. This is evident in Figure 2 as the region of the constant, unchanged stroke of the nozzle needle 12.

If, following on from this partially open state, the fuel-injection valve is to be moved to a completely open position for the purpose of the main-injection process, the valve needle 42 is then moved to its third position, in which both outlets 28, 34 are then open. The opening pressure acting upon the nozzle needle 12 can now move same to its completely open position, in which a comparatively large quantity of fuel can be injected.

If, following on from this completely open state of the fuel-injection valve, the nozzle needle 12 is then to be moved to its closed position, the valve needle 42 is returned to its first position, in which it lies against the valve seat 38. Thus, the fuel provided via the inlet 24 is accumulated in the control pressure space 22, so

that a correspondingly high closing force is exerted upon the actuating part and thus upon the nozzle needle 12. This is also illustrated in Figure 2.

Figure 3 illustrates a fuel-injection valve according to a second embodiment. The structure and the mode of function correspond substantially to the first embodiment, the only difference being that the arrangements of the outlet 34 and outlet 28 relative to the valve needle 42 have been exchanged. Thus, if the valve needle is located in its first position, in which it lies against the valve seat 38 and closes the outlet 28 of the control pressure space 22, no leakage flow can be produced over the guide of the valve needle.

CLAIMS

1. A fuel-injection valve having a valve body, a nozzle needle, which is disposed in a displaceable manner in the valve body, an actuating part, which is connected to the nozzle needle and protrudes into a control pressure space, and a control valve which can control the pressure in the control pressure space, the actuating part having a holding piston which can be displaced in a holding chamber and the control valve being a 3 port, 3 position directional control valve which controls both the outlet of the control pressure space and also the outlet of the holding chamber.

2. A fuel-injection valve according to claim 1, wherein the control valve comprises a control chamber, from which issues an outlet, a control pressure space-valve seat is formed on one side of the control chamber and a holding chamber-valve seat is formed on the other side of the control chamber, and disposed in a displaceable manner in the control chamber is a valve needle which can cooperate with the valve seats.

3. A fuel-injection valve according to any one of the claims 1 and 2, wherein a restrictor is provided in the outlet of the control chamber.

4. A fuel-injection valve substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.



INVESTOR IN PEOPLE

Application No: GB 0020028.7  
Claims searched: 1 to 4

Examiner: John Twin  
Date of search: 1 November 2000

## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK Cl (Ed.R): F1B (B2JCB, B2JCN)  
Int Cl (Ed.7): F02M 47/02, 59/46  
Other: online: EPODOC, JAPIO, WPI

### Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US 5975428 (Robert Bosch)	

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|---|--|
| X Document indicating lack of novelty or inventive step   | A Document indicating technological background and/or state of the art.  |
| Y Document indicating lack of inventive step if combined with one or more other documents of same category. | P Document published on or after the declared priority date but before the filing date of this invention.          |
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